

## PRECONTROL INVESTIGATION OF SCHISTOSOMIASIS IN CENTRAL SULAWESI\*.

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Pertama kali Oriental Schistosomiasis dilaporkan terdapat di Lembah Lindu, Sulawesi Tengah adalah pada tahun 1937. Studi tentang epidemiologi penyakit tsb. sampai perang dunia ke II menemukan bahwa selain orang, juga rusa dan anjing bertindak sebagai tuan rumah. Tetapi pada saat itu tuan rumah perantara belum diketemukan. Pada tahun 1971, lebih dari tiga puluh tahun sesudah penemuan *Schistosoma japonicum* di Lembah Lindu, penyelidikan tentang schistosomiasis di Sulawesi Tengah dimulai kembali. Tuan rumah perantara dari penyakit tsb. pada saat ini diketemukan dan setelah diselidiki ternyata merupakan sub-species baru dari *Oncomelania*, yang disebut *Oncomelania hupensis lindoensis*. Sesudah penelitian tentang penyakit tsb. dan dengan diketemukannya tuan rumah perantaranya, penelitian yang lebih mendalam tentang penyebaran schistosomiasis di Lembah Lindu dimulai untuk memungkinkan membuat rencana pemberantasan dikemudian hari. Karena schistosomiasis merupakan penyakit yang sangat kompleks, dalam arti menyangkut penyebabnya, tuan rumah perantara dan banyaknya hewan2 mamalia yang dapat bertindak sebagai tuan rumah tetap, maka penyelidikan tentang ekologi penyakit tsb. perlu dilakukan. Didalam paper ini akan terlihat garis2 besar dari penelitian yang sedang dilakukan di Sulawesi Tengah sebelum dilakukannya pemberantasan, antara lain Geographic distribution di Sulawesi, Mammalian host range, Prevalence rates and Intensity of infection in various mammalian host. Relative importance of mammalian reservoirs, Incidence in humans and rats, Distribution of molluscan host, Prevalence rates in the molluscan host. Population densities of molluscan host, Foci of transmission, Daily and Seasonal periodicity of cercarial release and Socio-economic factors affecting transmission.

Schistosomiasis is a comprehensive term applied to a disease caused by several species and strains of a parasite, all having identical life cycles. It is caused by certain digenetic trematodes which choose as their habitat the venous system of man. There are two clinical forms of the disease, the vesical and the intestinal. In the orient the disease, which is an intestinal form, is known as oriental schistosomiasis, Katayama fever, bilharziasis japonica and Yang-tze Valley fever. Schistosomiasis is accompanied by toxic and dysenteric symptoms, as well as loss of appetite and weight, emaciation and retarded growth of young patients. An enlarged liver and spleen, and

often ascites, are characteristics and are usually more pronounced in the oriental form than in the intestinal schistosomiasis of Africa, Central and South America.

Schistosomiasis first was reported from the Lindu Valley of Central Sulawesi, Indonesia by Müller and Tesch (1937). Early epidemiological studies prior to World War II demonstrated that, in addition to man, wild deer and domestic dogs served as reservoir hosts (Bonnet et al., 1942). The molluscan host, however, was not discovered. In 1971, over thirty years after the initial discovery of *Schistosoma japonicum* in the Lindu Valley, investigations of schistosomiasis in Central Sulawesi were reinitiated. The high prevalence of *S. japonicum* in the human population was reconfirmed (Hadi-djaja et al., 1972; Clarke et al., 1974). The molluscan host was found (Carney et al., 1973a) and subsequently described as a new subspecies of *Oncomelania*, namely *Oncomelania hupensis lindoensis* by Davis and Carney (1973). Following the confirmation of the

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human disease and the discovery of the molluscan host, a comprehensive study of schistosomiasis transmission in the Lindu Valley was begun in order that a rational control program

could be designed.

Schistosomiasis is a three-factor complex, involving an agent, an intermediate molluscan host and a mammalian definitive host (Fig. 1).

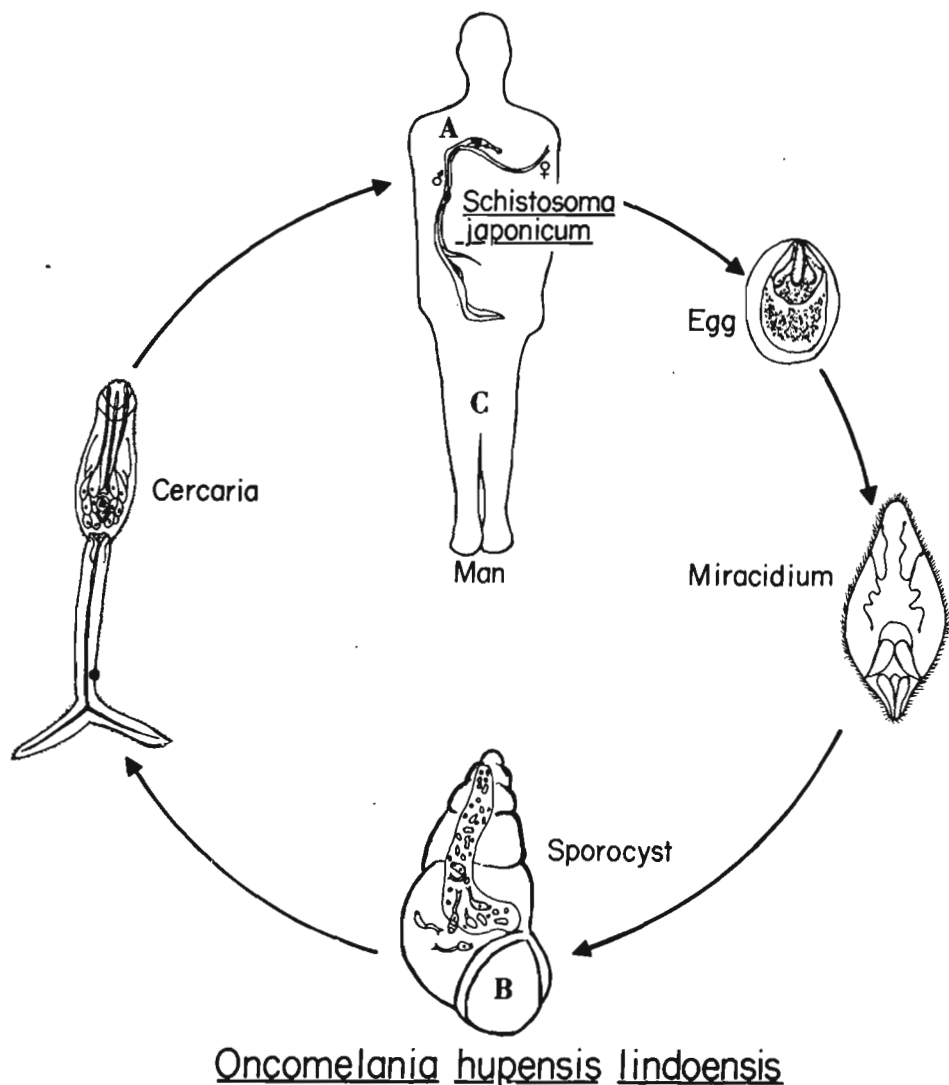


Fig. 1. Life cycle of *Schistosoma japonicum*. A. Copulating pair of *S. japonicum* inhabiting the upper mesenteric veins of definite host. B. Intermediate molluscan host, *Oncomelania hupensis lindoensis*. C. Definitive host represented by man, although any mammal that enters infested waters will probably serve as a definite host. Eggs of *S. japonicum*, after being passed from female worm into small veins, make their way into bowel of host, pass out with feces, and, if deposited in aquatic habitat, hatch, and release a motile miracidium. If a miracidium comes in contact with an oncomelaniid snail, it will penetrate and go through a series of asexual multiplications resulting in the production of larval worms, known as cercariae. These escape into an aquatic environment and penetrate the skin of mammals frequenting that habitat. Within the definitive mammalian host the cercaria metamorphoses into an adult schistosome, mates and, thus, completed the life cycle.

Oriental schistosomiasis is a zoonosis involving a wide range of mammals. Most likely any mammal which frequents infected waters will serve as a host for the adult stage of this blood fluke. Since schistosomiasis was known to be complex involving an agent, an intermediate host and a wide range of definitive hosts, an ecological approach to the study was taken.

Specific objectives were (1) to document the endemicity of *S. japonicum*, e.g. the prevalence rates in man, wild and domestic reservoirs and in the molluscan host, as well as the intensity and incidence of infection in man, domestic and wild mammals; (2) to study the ecology of transmission, e.g. the distribution of infected humans, wild and domestic animals and the molluscan host, population dynamics of the molluscan host, the possible role of other freshwater and/or amphibious mollusks in transmission, as well as natural predators, parasites and diseases of the molluscan host;

(3) to determine the dynamics of transmission, e.g. the rate of egg production and hatchability in humans, domestic and wild mammals, the relative transmission index for humans, wild and domestic animals, the daily and seasonal periodicity of cercarial production and release in the field as well as the survival and distribution of cercariae in the field; and (4) to illustrate the social and economic factors affecting transmission such as domestic and economic contacts with water and local agricultural practices affecting transmission.

Current investigations, carried out under the auspices of the Ministry of Health, the University of Indonesia and NAMRU-2, have screened stool specimens from approximately 7,000 persons from South and Central Sulawesi. After reconfirming schistosomiasis in the Lindu Valley, an entirely new schistosomiasis region was discovered in the Napu Valley (Carnegie et al., unpublished data) (Fig. II). The Napu

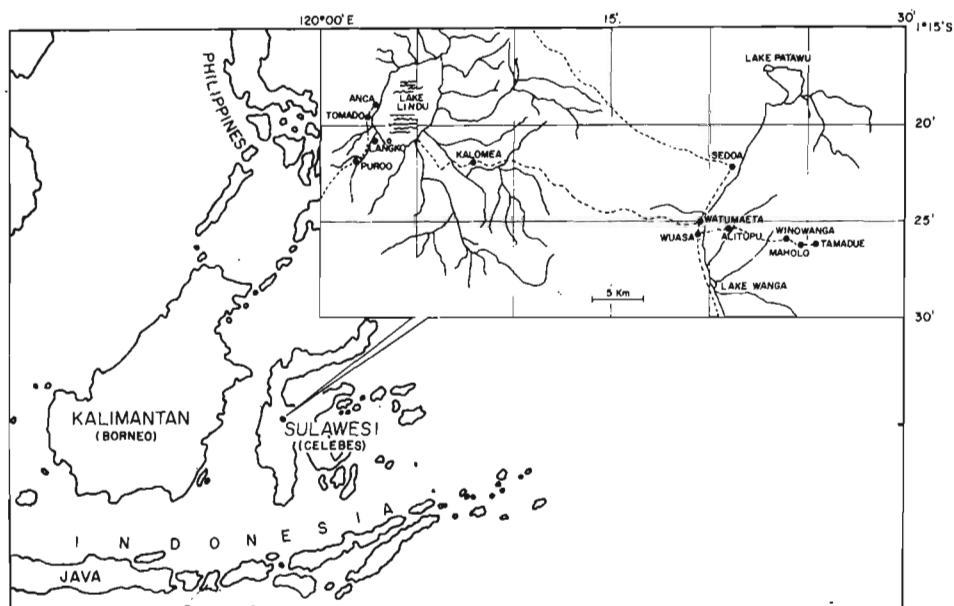


Fig. II. Map of Sulawesi, Indonesia, detailing the Lindu and Napu areas where *Schistosoma japonicum* is endemic.

Valley is a remote high mountain valley only 50 Km southeast of Lindu, but in a different and much larger drainage system,

which drains via the Lariang river into the Strait of Makassar. The Napu Valley is extensive in comparison with the Lindu Valley. Less than

0 Km<sup>2</sup> of the Lindu Valley are moors and lowlands needed for *O. hupensis* habitat, whereas in the Napu Valley there appears to be 5,000 Km<sup>2</sup> of suitable topography. Thus, it could be conservative to estimate that the schistosomiasis area of Napu Valley is potential 50 to 100 times greater than that in the Lindu Valley.

In addition to surveys in the Lindu and

Napu Valleys, stool specimens of more than 5,000 persons from other areas of Central and South Sulawesi recently were examined (Fig.III). In the Palu and Kulawi Valleys (Cross et al., unpublished data), epidemiologically important because they are situated in the same drainage system as Lake Lindu, a few cases of schistosomiasis were found. In each case, however,

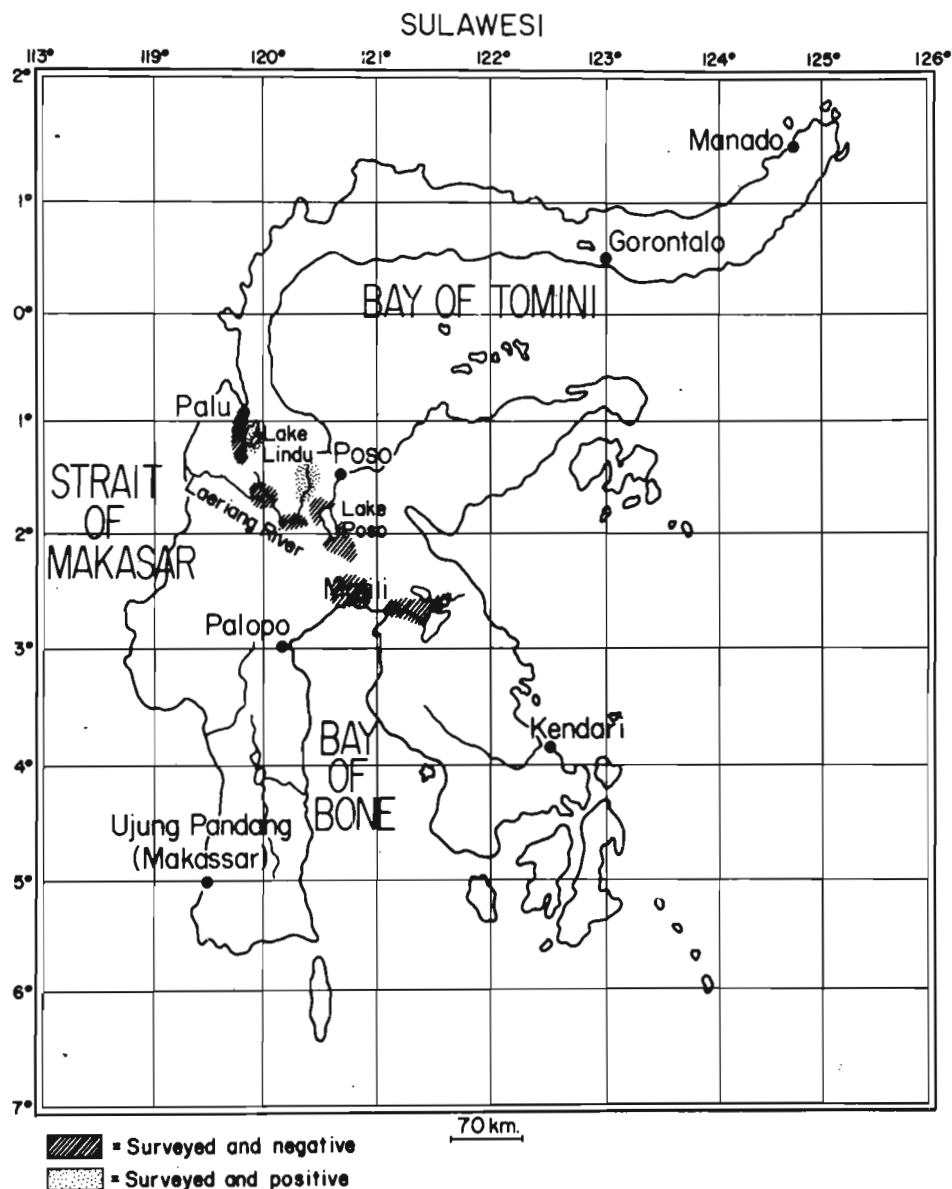


Fig. III. Map of Sulawesi illustrating areas surveyed for schistosomiasis.

the individual was found to have spent considerable time visiting or working in the Lindu Valley. This was understandable since a substantial number of Kulawi residents own and work paddy fields in lowlands southeast of Lake Lindu. On the Lariang river system, which drains the Napu Valley into the Strait of Makassar, stool specimens from residents of the Gintu and Gimpu Valleys were collected and examined (Carney et al., unpublished data). Neither area yielded a single case of schistosomiasis, even though they are located downstream from known foci in the Napu Valley. Further east in the Poso Valley drainage, which is situated in the center of Sulawesi between the Bay of Tomini and the Bay of Bone, five villages were surveyed (Carney et al., unpublished data). Even though the topography around Lake Poso is similar to the Lindu Valley, not a single case of schistosomiasis was found. Surveys also were conducted in the region of Lake Matano and Lake Towuti, east of Malili, (Joseph et al., unpublished data), and in the Margolembo area, west of Malili on the coast of the Bay of Bone (Cross et al., 1972) but again schistosomiasis cases were not discovered.

In the Far East, dogs, cats, rats, mice, cattle,

water buffalo, pigs, horses, sheep and goats are naturally infected and have long been known to act as reservoir hosts for *S. japonicum*. Reservoir hosts are significant in the transmission of this disease, because humans, domestic and wild mammals all frequent areas, which harbor the molluscan host and leave their excreta in these amphibious or aquatic habitats.

Man, of course, is one of the predominant mammals in the Lindu Valley serving as a reservoir for the adult stage of *S. japonicum*. So far, 12 species of domestic and wild mammals other than humans have been examined. Of these, nine species have been found to serve as reservoir hosts, namely *Rattus exulans*, *R. hoffmanni*, *R. chrysocomus rallus*, *R. musurus*, wild deer, wild pigs, civet cats, cats and dogs (Carney et al., 1973b).

Mammalian surveys have been primarily geared to determine the distribution and infection rates in rodents, principally *R. exulans*, which inhabit the cultivated and uncultivated lowlands. Precise locality records for infected rodents, because of their limited ranges, have been used to zero-in on foci of transmission through intensive follow-up snail surveys.

Infected mammals have been found along the entire western and northern borders of Lake Lindu (Fig. IV).

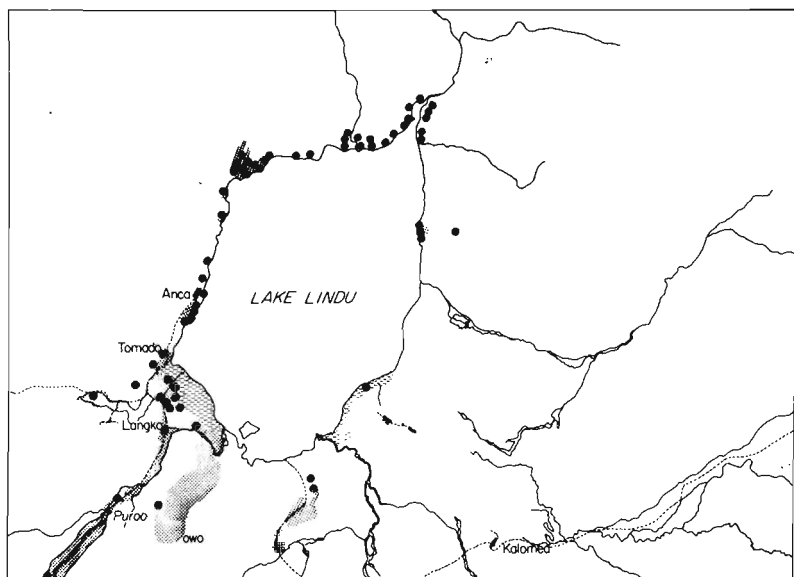


Fig. IV. Map of Lindu valley illustrating locations where mammals infected with *Schistosoma japonicum* have been captured.

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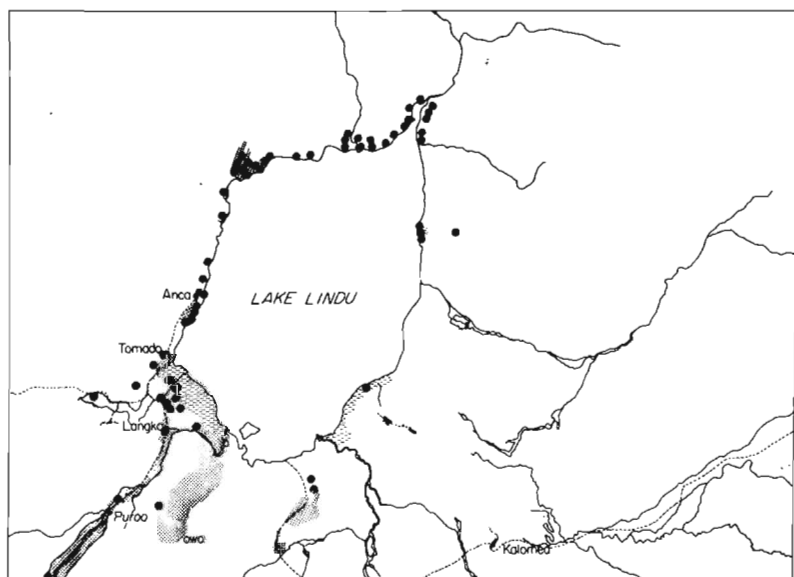


Fig. IV. Map of Lindu valley illustrating locations where mammals infected with *Schistosoma japonicum* have been captured.

Limited records along the eastern coast and the extensive lowlands on the southeastern coast reflect the impenetrability of that region. Intensive surveys of the eastern region. If they are feasible, will undoubtedly yield naturally infected rodents along the entire perimeter of the valley.

Schistosomiasis is still very prevalent in the Lindu Valley; 38% had schistosomiasis based on the analysis of a single stool specimen (Clarke et al., 1974). Infection rates ranged from 57% in the villages of Anca to 12% in the village of Puroo. The high prevalence in Anca was expected since the inhabitants of Anca are known to work in paddy fields where there are many well established colonies of *O. h. lindoensis*. Likewise, the relatively low infection

rate in Puroo was expected since Puroo is a transmigration settlement of less than 10 years and few oncomelanid colonies were found in that region.

The molluscan host obviously plays an important role in the epidemiology of schistosomiasis, as the snail is associated with a significant part of the life cycle of the schistosome from the miracidial to the cercarial stages. Certain aspects of snail biology thus have been stressed, namely geographical distribution, population densities and prevalence rates of infections with *S. japonicum*. Oncomelanid snails are widely, but focally, distributed throughout the Lindu Valley (Fig. V) (Carney et al., 1973 b).

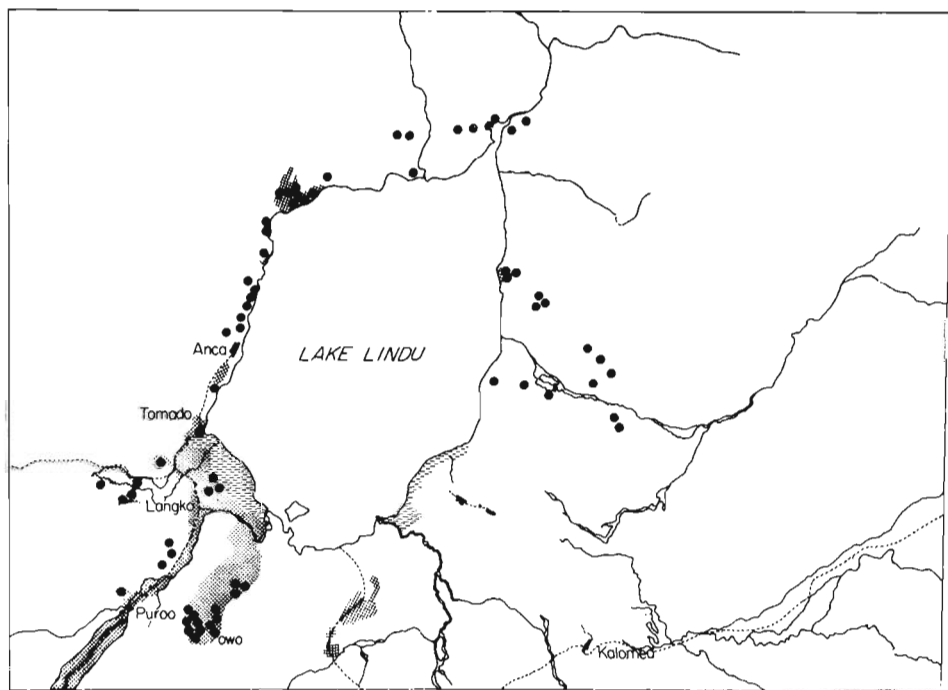


Fig. V. Map of Lindu valley illustrating known foci of *Oncomelania hupensis lindoensis*.

Over 50 foci have so far been isolated in the lowlands surrounding the lake. Most of the snail colonies were found on the western side of the lake, however, the vast lowland marsh on the eastern side has not been extensively surveyed due to its limited accessibility. Un-

doubtedly oncomelanids will be found in similar niches along the entire perimeter of the valley. Oncomelanid habitats in the Lindu Valley can be grouped into two general categories, namely disturbed area foci and natural foci.

Many colonies were found on uncultivated, yet cleared, grassy fields with a rich silty soil adjacent to actively worked paddy fields (Fig. VI)



Fig. VI. Focus of *O.h. lindoensis* in uncultivated area adjacent to actively worked paddy fields.

The grass cover was sufficiently dense and high to offer adequate protection, since oncomelaniids were usually abundant in this habitat. Although these foci were frequently flooded by rains and during the irrigation of adjacent paddy fields, they were often entered by humans and domestic animals.

Abandoned paddy fields in swampy regions also served as ideal breeding foci for oncomelaniids, whereas fallow paddy fields did not appear to support the growth and development of this species (Fig. VII).



Fig. VII. Abandoned paddy fields which serve as suitable habitat of *O.h. lindoensis*.

Apparently the substrate of disturbed areas must be stabilized and the flora sufficiently dense to provide suitable habitat. Oncomelaniids have not yet been found in actively worked paddy fields, even though adjacent

grassy fields supported high populations.

Dense vegetation adjacent to irrigation ditches, which formed a network throughout cultivated lowlands, also supported oncomelaniid colonies (Fig. VIII).



Fig. VIII. Dense vegetation on both sides of irrigation ditches support oncomelaniid colonies.

It appeared that oncomelaniids migrate from these small ditch bank colonies into grassy fields, after they had been abandoned for a few seasons. Disturbed areas represent a secondary adaptation for oncomelaniids. In the Lindu Valley oncomelaniids thrive along irrigation ditches, overflow areas, such as abandoned paddy fields, cleared grassy areas between paddy fields and native cane breaks. Undoubtedly disturbed areas of today, located on the vast marshland and moors remaining after the lake receded to its present level, were natural habitat for oncomelaniids before wet rice, cultivation was introduced in the early 1900's.

Natural foci of oncomelaniids were found in a variety of undisturbed areas, chiefly in an ecotonal zone between the forest and lowlands (Fig. IX).





Fig. IX. Natural focus of *O.h. lindoensis* in ecotonal zone of forest and scrub vegetation.

Natural habitats were well shaded by medium and high tropical vegetation. In contrast to disturbed areas, the temperatures of natural foci were much more constant and generally cooler. Usually, natural foci were spring fed areas with a silty substrate that remained moist throughout the entire year. Oncomelanids were found crawling over the silty oil or attached to tanned leaves or any other flotsam available.

Although the majority of natural foci were found in ecotonal areas between the forest and lowlands, some foci were located in small pockets where the forest vegetation bordered the lake shore (Fig. X). Natural foci also were found on rock slides bordering the lake shore. The substrate of these foci was typically sandy with medium size stones scattered about. Oncomelanids were found crawling on the rocks, under the surface of tanned leaves, dead branches or any other flotsam in these spring fed areas. These foci, likewise, were well shaded by the medium and high forest canopy that borders the lake shores. Temperatures were constant and cooler than in the disturbed area foci.

Infection rate of *S. japonicum* in oncomelanids varied considerably between foci and throughout the year. Infection rates ranged from 0 to 80 per cent. Usually infection rates were less than 10 per cent in the larger colonies



Fig. X. Natural focus of *O.h. lindoensis* in lowland forest bordering lake shore.

of disturbed areas while higher rates were frequently recorded for small natural foci in virgin lowland forests and ecotonal zones. In disturbed area foci infection rates were higher in the dry season, usually June through October, than during the rest of the year. In natural foci, however, infection rates were more constant throughout the seasons.

Studies were initiated to determine the population densities of *O.h. lindoensis* in a series of foci throughout the Lindu Valley. Seven areas, representing both disturbed areas and natural foci, were sampled each month using a man/minute method to estimate population densities. This method has one serious weakness — human frailty, for it depends on the reliability, care and accuracy of the collections. However, this method has the advantage of being suited to almost every type of habitat and is, moreover, relatively simple, requires only simple tools,

and facilitates reasonably accurate and useful snail population estimates in a rather short time.

Populations of amphibious snails, such as *O. h. linduensis*, are best estimated by the use of small quadrats. In habitats frequently covered with water or consisting of densely matted vegetation, such as at Lindu, it is necessary to take the plugs of mud, water and vegetation and screen them for snails. This method is time consuming, but more accurate, since fewer small snails are missed. Ring samplers, which have been used with success in other Asian countries (Pesigan et al., 1958), have not worked well at Lindu. An accurate quadrat method, however, is essential for studies of snail population dynamics where age and sex data are necessary.

Changes in the rate of transmission are most rapidly detected by the measuring of the incidence of the infection, e.g. the rate at which uninfected people become positive. Pre-control rates of incidence are being calculated on the basis of a yearly stool examination of children less than ten years of age. However, in favorable circumstances it is possible, and simpler, to use the prevalence of infection in small, short-lived mammals to measure the incidence as well as the intensity of transmission. *Rattus exulans*, which is ubiquitous throughout the Lindu Valley in both disturbed and natural foci and susceptible to *S. japonicum*, should serve as a good index since its average life span is considerably shorter than one year. *Rattus exulans* now is being trapped monthly from a series of known foci to establish precontrol infection rates in this small rodent.

Daily and seasonal periodicity of cercarial release are being measured by animal exposure. White mice are exposed to infected waters throughout a 24 hr. period each month. After 50 days the mice are sacrificed to determine if infected or not.

The relative importance of the various mammalian reservoirs will be determined by the calculation of a relative transmission index. However, this aspect of the study has not been initiated. When completed, this aspect of the study will define the role of reservoirs, including

man, in maintaining the transmission of *S. japonicum* in the Lindu Valley.

Social and economic factors influencing the transmission of schistosomiasis in the Lindu Valley have been investigated. Wet rice cultivation was introduced to the Lindu Valley after 1900. During the rice growing season practically the entire Lindu population moves into small paddy field houses in the immediate vicinity of their fields. These houses are frequently adjacent or downstream from known foci of schistosomiasis transmission.

Although Lake Lindu is a clean, beautiful, fresh water lake, the Lindu residences prefer to wash, bath and defecate in the small paddy field streams which run adjacent to their houses. Likewise, domestic animals, such as dogs, live in close association with man at Lindu. Rats are also very abundant in and around the paddy field houses. Both of these mammals are confirmed reservoirs of schistosomiasis. The close association of humans and other mammalian reservoirs in the paddy field situation and the complete lack of sanitary disposal of human excreta continually seed the paddy field areas with schistosome eggs, which, in turn, maintain relatively high infection rates in the oncomelanid populations. Frequent entry into these infected waters in the course of daily and seasonal activities, likewise, maintains a very high infection rate in the human population of the Lindu Valley.

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#### SUMMARY

The known distribution of *S. japonicum* in Indonesia is limited to the Lindu and Napu Valleys, both of which are high, remote moun-

tain valleys in Central Sulawesi. Current investigations have incriminated nine species of mammals, other than man, as reservoir hosts of oriental schistosomiasis in Sulawesi, namely: four species of rats, wild deer, wild pigs, civet cats, cattle and dogs. Prevalence rates of *S. japonicum* are high both in man and other mammals. The molluscan host, *O.h. lindoensis*, is abundant and widely distributed throughout

the Lindu Valley in both natural and disturbed area habitats. Occupational necessities and personal habits of Lindu residents frequently bring them in contact with infested waters. Studies on various aspects of the dynamics of transmission, the relative roles of various reservoirs in continuing the transmission of schistosomiasis are being investigated or will be initiated in the near future.

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